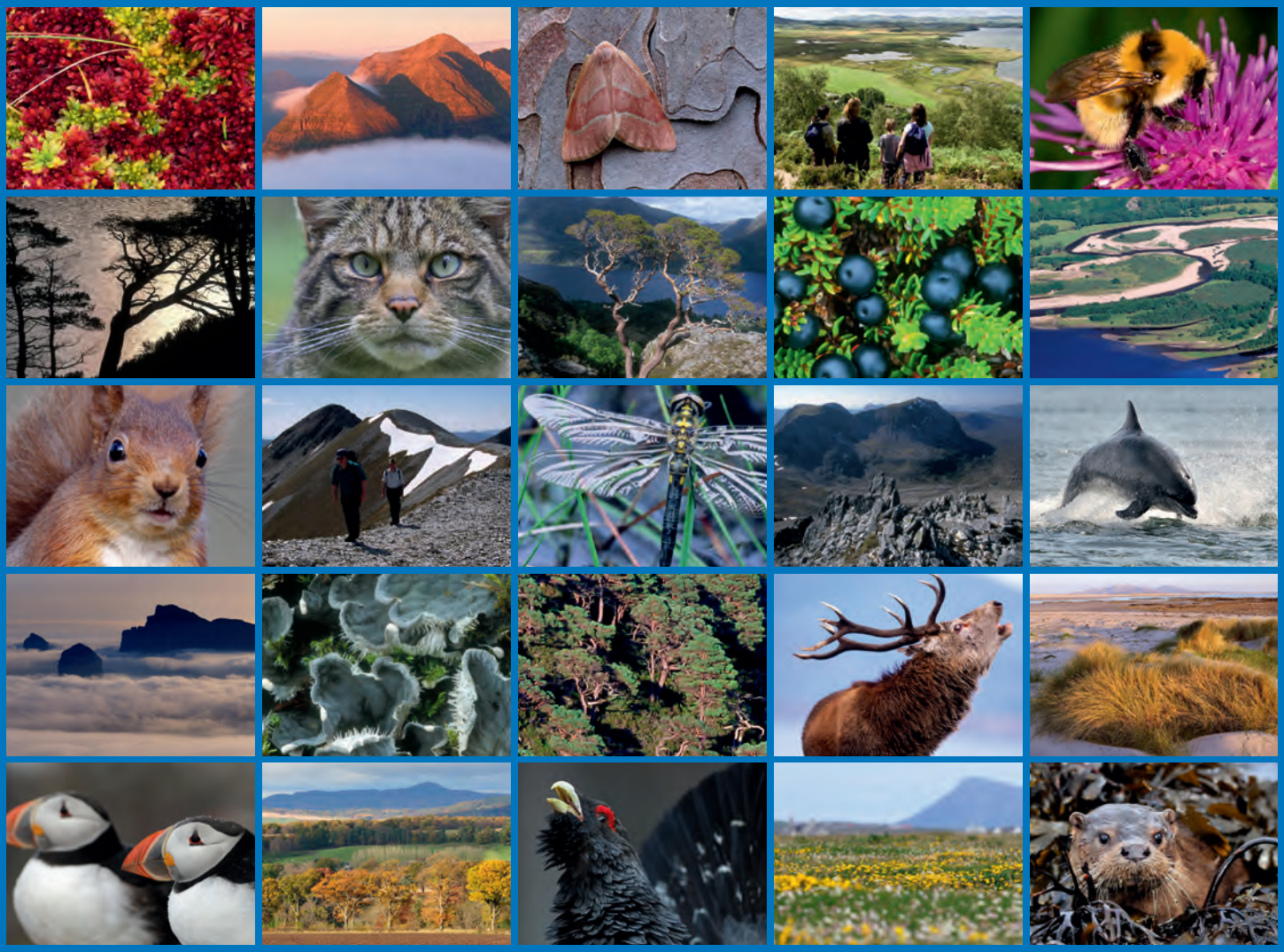
Scottish Natural Heritage
Commissioned Report No. 715

Investigation of Standing Water and Wetland SSSIs thought to be under Diffuse Pollution Pressure: Branxholme Wester Loch



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COMMISSIONED REPORT

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Investigation of Standing Water and Wetland SSSIs thought to be under Diffuse Pollution Pressure: Branxholme Wester Loch

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COMMISSIONED REPORT

Summary

Investigation of Standing Water and Wetland SSSIs thought to be under Diffuse Pollution Pressure: Branxholme Wester Loch

Commissioned Report No. 715
Project No: 13700
Contractor: EnviroCentre Ltd.
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Keywords

Diffuse pollution; SSSIs; wetland; water; soil; samples; recommendation.

Background

SNH contracted EnviroCentre to look at a number of SSSIs across Scotland thought to be adversely affected by diffuse pollution. EnviroCentre was asked to carry out a number of tasks to help SNH understand better whether sites are being affected by diffuse pollution and if so, what activities might be contributing to this pressure and how SNH could improve the condition of the sites.

If sites are identified as being affected by diffuse pollution, SNH hope that the results of this report will help them to work with managers of the sites to improve their condition.

Main findings

- The desk study and site walkover identified potential existing and historical land use practices within the catchment that could adversely affect water quality and soil nutrient status. This included long-term changes resulting from agricultural and forestry management practices within the catchment.
- Analytical data confirmed the presence of elevated nutrients. It should be noted that the sampling assessment was undertaken as a single visit and the limited scoped dataset and a lack of historical data constrains the ability to draw accurate conclusions to fully inform current site conditions.
- A series of recommendations are proposed to seek to aid the understanding of the site and afford a greater insight into the perceived changes taking place within the SSSI.

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Acknowledgements

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Thanks are also extended to the site landowners for affording access to the site to enable the agreed scope of work to be undertaken.

1. INTRODUCTION

EnviroCentre Ltd was contracted by Scottish Natural Heritage (SNH) in August 2012 to deliver the 'Investigation of Standing Water and Wetland SSSIs under diffuse pollution pressure' project. The data collected from the project will be used to inform management decisions on wetland and standing water Sites of Special Scientific Interest (SSSI).

1.1 Site Location

Branxholme Wester Loch is located approximately 9km south west of Hawick. See Figure 1.1 in Annex 1.

1.2 Site Description

Branxholme Wester Loch Site of Special Scientific Interest (SSSI) is an oligotrophic upland loch occurring at an altitude of 267m, with one of the widest range of associated fen and bog vegetation communities in the Borders. The area of the site is 10.45ha (SNH, 2010b) and has been notified as a SSSI for its extensive and particularly good representation of habitats which exemplify the gradual change from open water to waterlogged but terrestrial habitats – *i.e.* an open water transition fen habitat (SNH, 2010a).

The site is a component of the Whitlaw and Branxholme Special Area of Conservation (SAC), classified for the habitat types 'Very wet mires', 'Base-rich fens' and the bryophyte 'Slender green feather-moss (*Drepanaocladus (Hamatocaulis) vernicosus*)' (SNH, 2010b).

Arranged in typical concentric zonations are common reed and sedge swamp fringing the open water, then vegetation rafts (quaking bog) floating on a liquid peat/silt substrate; slender sedge (*Carex lasiocarpa*) - brown moss dominated rich-fen and also poor-fen with scattered willow carr, birch and the odd conifer, which surrounds a central area of developing sphagnum-rich raised bog. On peripheral slopes around the fen, flushed (lime-enriched) seepages and deep spring-heads or "well-eyes" arise. These support characteristic moss and invertebrate species (SNH, 2010a).

The loch is fringed by bottle sedge (*Carex rostrata)* and common reed (*Phragmites australis*) swamp, with an unusual stand of common club-rush (*Schoenoplectus lacustris*) on the north side. Shoreweed *Littorella* meadows occur along the shallow eastern shore. The site supports a number of other nationally scarce plant species including stoneworts (*Chara spp.*) and pondweeds (*Potamogeton spp.*) in the loch, and sedges, an orchid and bryophytes (mosses and liverworts) in the fen or bog. Over 50 aquatic water beetle species and a number of other uncommon aquatic invertebrates have been recorded (SNH, 2010b).

The bedrock geology on site is composed of Gala Group and Hawick Group Wacke. Where superficial deposits are present on site they take the form of Glacial Till (British Geological Survey, n.d.).

1.3 Site Hydrology

A catchment area of 0.39km^2 drains to the site, with an annual average rainfall of 1,039mm (Centre for Ecology and Hydrology, 2009). There are two main inflows to the site, one burn flows from the south west to enter the loch at the southern end, the other burn enters the site in the north east (running through the plantation), both are unnamed. An additional source of inflow to the site is overland flow from adjacent forestry and agricultural land. The Newmill Burn forms the outflow from the site, flowing to the west.

1.4 Site History

The land around the site is managed extensively for sheep and cattle grazing. A Management Agreement exists between the Buccleuch Estates and SNH. The Agreement, which commenced in 1992, is for 60 years and covers an area of 18.2 ha, including the conifer plantation outwith the SSSI. Its aim is to preserve and maintain the special scientific interest of the loch habitats by maintaining fencing in order to exclude livestock and managing forestry operations in consultation with SNH.

The area of raised bog has undergone historical disturbance by peat cutting, but it is regenerating well (SNH, 2010a).

1.5 Recent Site Management Practices

The SSSI and the management agreement area can be divided into three compartments. A narrow southern strip outwith the fence is lightly grazed by sheep as part of the much larger tenanted open hill area. The rest of the site is in-hand and managed by the Estate and includes the central ungrazed compartment and the north-eastern area comprising the plantation where normal forestry management takes place. Both the latter compartments are fenced from grazing stock. The existing management agreement does not include any active management on the site.

The plantation was felled and re-stocked with conifers in 2002, in consultation with SNH. The new planting included a buffer zone of mixed native broad-leaved species such as cherry, rowan and willow on two sides of the loch. The drainage system was altered to prevent silt and nutrient releases into the loch during felling, but also resulted in the temporal diversion of water away from the loch. By blocking and re-directing drains in 2007, water is now allowed to filter through the buffer zone and into the loch before exiting via the Newmill Burn. Normal water levels were expected to be restored since there are no other known man-made influences on the water regime.

Pheasant shooting, control of rabbits, roe deer, crows, pigeons and mink are known to occur but the activity is not known to cause problems. Occasional casual angling takes place, unconsented by the owners. However, at low levels this is not a problem for the loch feature. Public access around the loch is possibly increasing and there is an old hide on the west side of the loch (SNH, 2010a).

Some remedial felling of birch scrub and some larger pine trees was undertaken in March 2011 in order to assist in maintaining a high water table. In 2012 SNH agreed with Buccleuch Estates that reed would be treated with glyphosate in late summer 2012. It was considered that further treatment in subsequent years may be needed (SNH, 2012).

2. METHODOLOGY

The following sections outline the approach undertaken to fulfil the scope of works established by SNH in the Statement of Requirements (SOR).

2.1 Pre-site Attendance Desk Study

Before the initial site visit was undertaken the local SNH officer was contacted and a meeting held at the corresponding local office to discuss the local understanding of the site and review SNH records.

The meeting was also used to provide an insight into any health and safety constraints not readily apparent from the site maps.

Landowners of the site were notified of the planned site visit a week before the proposed visiting date. This allowed landowners the opportunity to ask any questions and also gave EnviroCentre staff a chance to gain a greater understanding to the workings of the site and the site surrounds. Landowner details are provided in Annex 2.

2.2 Site Attendance

The site was accessed and samples collected over a one day period – termed Visit 1. A follow up visit to the wider catchment – Visit 2 was undertaken once the analytical data was available and was appraised in context with the information obtained from the desk based exercise.

Table 2.1 below shows site conditions on the day of each visit.

Table 2.1: Site Conditions

Site Name	Date of Visit	Weather Conditions	Grid References
Visit 1	7/11/2012	Cold, overcast, rain	NT 422 109
Visit 2	12/03/2013	Cold, overcast, dry.	NT 422 109

2.3 Sampling Approach

SNH had determined the preferred locations for the collection of soil and water samples – as detailed in Figure 2.1 in Annex 1. EnviroCentre was not involved in determining these locations and had not assessed the suitability to access such before Visit 1. Due to certain restrictions, the locations of samples that EnviroCentre collected had to be changed and are as detailed in Figure 2.2 in Annex 1. Changes to locations were kept to a minimum and are generally not deemed to have a significant impact on the sampling or conclusions.

All sampling methods were carried out by trained personnel. Photographs of each sampling location were taken (see Figure 2.3 in Annex 1) and grid references for each location recorded.

2.4 Sample Equipment

The following sample kit was used to undertake site field work:

- Handheld GPS to record specific grid references;
- Handheld soil augers;
- Plastic bailers;
- Sample bottles (all sample bottles were written on to record locations, date and time); and

- Personal Protection Equipment (in line with the requirements of the site specific health & safety risk assessment).

All samples were given unique identification names and packaged in cool boxes with ice packs so as to keep samples at appropriate temperatures prior to being despatched to a United Kingdom Accreditation Service (UKAS) accredited laboratory for analysis.

2.5 Health and Safety

Site specific risk assessments were carried out before attending site. The assessment was based on information obtained from the meeting with the local officer and from EnviroCentre's extensive experience of undertaking previous work of this nature.

The risk assessment, which was carried out by staff attending the site visit, included details of the landowner, nearest emergency services and identified risks and proposed means of mitigation. Field operatives notified EnviroCentre head office when entering and leaving site and wore the following appropriate PPE at all times:

- Warm and waterproof clothing;
- Waders;
- Waterproof footwear; and
- Hi-vis vest.

Biosecurity measures were implemented when entering and leaving site. Boots and equipment were washed when leaving site so as not to cross contaminate subsequent sites.

2.6 Water Samples

Surface water samples were collected from strategic locations within the site boundary to provide an understanding for the whole site, comprising inflows, open water and outflows.

Groundwater samples were collected using plastic bailers from slotted pipes installed with hand augered holes where soil samples were originally collected. The sampling methodology employed a geosock membrane for coarse filtration so as to minimise samples being heavily loaded with suspended solids and organic material.

Samples underwent initial on-site field tests using an OTT Quanta Handheld probe for the following parameters:

- pH;
- Temperature;
- Electrical Conductivity (EC);
- Dissolved Oxygen (DO);
- Oxidation-Reduction Potential (ORP); and
- Salinity.

The water samples were submitted for the following analyses to a UKAS accredited laboratory:

- Total calcium (Ca), magnesium (Mg) and sodium (Na);
- N Species – total nitrogen, nitrate and ammonium;
- P Species – orthophosphate and total phosphorus; and
- Total iron (Fe).

Dissolved and ferrous iron analyses were scheduled in but could not be undertaken by the laboratory due to insufficient sample. This data would have supported interpretation of results if available but is not considered critical for determining the presence or potential sources of diffuse pollution.

2.7 Soil Samples

Soil samples were collected from specific locations on site by hand augering holes into the ground. The soil samples were collected at two depths:

- The rooting zone; and
- A depth of approximately one metre below the rooting zone.

  NB - In the corresponding results tables the samples are differentiated by the suffix 'A' for the rooting zone; and 'B' for below the rooting zone.

Soil samples were analysed for the following suite:

- Moisture Content;
- Extractable nitrogen and phosphorus;
- Total nitrogen and phosphorus; and
- Total calcium (Ca); magnesium (Mg) and potassium (K).

Bulk density analysis was scheduled in but could not be undertaken by the laboratory due to insufficient sample. Total sodium (Na) and total organic carbon (TOC) were not scheduled in properly and analyses were not undertaken. The lack of this data is not considered to affect interpretation of results in terms of determining the presence and potential sources of diffuse pollution.

2.8 Field Observations

On accessing the site for the first visit, and the wider catchment for the second visit, the following field observations were noted:

- Geo-referenced photograph locations of surrounding land use (refer to Figure 2.4 in Annex 1) ;
- Adjacent land use;
- Identified and potential pollution sources; and
- Atypical or unusual site features (*e.g.* fly tipping, vandalism, *etc*.).

In addition, mapping of the immediate surrounding catchment was completed following the second site visit (see Figure 2.5 in Annex 1). This process utilised the Flood Estimation Handbook (Centre for Ecology and Hydrology (CEH) 2009) catchments and Land Cover data (Land Cover Map 2007) to populate GIS mapping. The output was used to aid the interpretation of results and further inform the study conclusions.

3. STUDY LIMITATIONS

The scope of the commissioned study presented a series of limitations which should be borne in mind when reviewing this report. These are outlined below:

- Sampling was undertaken on a single visit. Whilst this afforded consistency for the samples collected, the weather conditions preceding and at the time of the visit may have directly influenced the observations made and the analytical results obtained.

- For the same reasons outlined above, access to certain parts of the site may have been restricted and limited access to the predetermined sampling location.

- Sampling comprised a single set of samples from each of the pre-determined locations. Repeat or continuous sampling over an extended (seasonal) period would be preferred to enable a greater dataset to be collected. This would present a more representative assessment of the site and allow for seasonal/climatic variations.

- The dataset provides a 'snapshot' of the site condition. Due to the limited availability of historical data (see section 1.4) there is very limited scope for comparisons to be made with previous records or allowance for assessment of seasonal or climatic factors.

- The scope of work did not include the assessment of rainfall within the catchment, measured water levels or the inflow(s)/outflow(s) of associated watercourses.

- The limited dataset does not allow for any statistical analysis of the results to be undertaken. No adjustment has been made for anomalous results or to determine trends over time.

- The sampling methodology used to obtain groundwater samples (obtained from a circa. 1m depth coupled with geosock membrane for coarse filtration) typically results in these samples being heavily loaded with suspended solids and organic material meaning that the samples appear 'dirty' to the naked eye. To avoid interference with the laboratory analytical instrumentation and erroneous results, on receipt at the laboratory these are processed on a x10 dilution. It is this dilution process which explains why some of the results are reported as a less than value rather than the equivalent level of detection of 'clean' samples. The same dilution approach is applied to heavy silted surface water samples.

- The weather conditions prior to and during the site visit should be taken into consideration when reviewing the results. According to the Met Office (n.d.) the seasonal rainfall totals for summer, autumn and winter 2012 in eastern Scotland were 161%, 89% and 82% respectively of the annual average rainfall levels for the period 1981-2010. This should be taken into consideration when reviewing the results as it could result in bias when compared with years where average rainfall levels were recorded. The higher rainfall will directly influence runoff, dilution and catchment water levels/throughput which have not been assessed.

- Due to limitations in the mapping data used to compile the Flood Estimation Handbook (FEH) catchment boundary, the area defined in the Annex 1 maps does not necessarily present an accurate reflection of the hydrological catchment for the site. Whilst this affords a valuable tool for the purposes of this study, the mapped boundary should be viewed as an indicative guide only and be subjected to detailed verification to be considered definitive.

4. ANALYTICAL DATA

The following tables show the results obtained from the initial site visit (Visit 1) in which samples from the pre-determined locations (or as close to as practically possible) were collected. Where the pre-determined locations were not accessible comparable alternative locations with the same habitat features were sampled.

Table figures in red indicate relative atypical (*e.g.* high or low values) or anomalous results relative to the remaining dataset or which would typically have been expected to be observed from a site of this nature. These are discussed further in section 6.2.

4.1 Water Quality Field Data

The following data was collected by a suitably qualified operative using the methods outlined in section 2.

Table 4.1: Field Data

Sample ID	Nat. Grid Reference		Temp (°C)	pH	Salinity (psu)	DO (%)	DO (ppm)	ORP (mV)	EC (µS/cm)	General Field Observations
Branx01	NT 42205	10995	10.06	7.66	0.09	66.5	7.3	-128.5	0.181	Surface water - clear with some fine and larger suspended solids; no odour
Branx02	NT 42289	10922	10.27	7.99	0.08	82.0	9.18	233	0.181	Surface water - very slightly discoloured with some minor suspended solids; no odour
Branx03	NT 42297	10922	9.57	7.93	0.21	*N/A*	*N/A*	247	0.443	Groundwater - milky brown with very fine suspended solids; no odour
Branx05	NT 42113	10836	9.84	7.81	0.15	*N/A*	*N/A*	248	0.328	Surface water - clear with only a few very minor suspended solids; no odour
Branx06	NT 42082	10906	9.98	6.04	0.08	*N/A*	*N/A*	248	0.166	Groundwater - cloudy dark brown, fine brown suspended solids; no odour
Branx07	NT 41980	10916	9.68	6.89	0.30	*N/A*	*N/A*	194	0.740	Surface water - clear with some organic suspended solids including leaves; no odour

DO meter calibration malfunction for Branx03, Branx05 & Branx06 and Branx07
No field data available for Branx 08

4.2 Laboratory Results

The data in the following tables was collected by a suitably qualified operative using the methods outlined in Section 2.

Table 4.2: Water Samples – Laboratory Analysis

Sample ID	Nat. Grid Reference		Sample Type+	Total Ca (mg/l)	Total Mg (mg/l)	Total Na (mg/l)	Total Fe (mg/l)	Amm N (mg/l)	Nitrate as N (mg/l)	Phosphate as P (mg/ l)	Total P (mg/l)	Total N as N (mg/l)
Branx01	NT 42205	10995	SW (OW)	29	8	4	<0.01	0.01	0.3	<0.01	<0.1	1
Branx02	NT 42289	10922	SW (O)	28	8	3	0.02	0.01	<0.2	0.09	<0.1	<1
Branx03	NT 42297	10922	GW	26	26	6	65.8	0.09	<0.2	0.13	0.2	<1
Branx05	NT 42113	10836	SW (I)	46	12	4	0.14	0.01	<0.2	0.04	<0.1	3
Branx06	NT 42082	10906	GW	43	27	<10	62.4	<0.01	<0.2	0.14	3.3	<1
Branx07	NT 41980	10916	SW (I)	42	10	4	0.09	0.01	<0.2	0.02	<0.1	<1
Branx08	NT 42156	11085	GW	88	26	<10	26.7	0.30	<0.2	0.01	1.1	<1

+ Surface water samples are designated either inflow (I) or outflow (O).

No shallow groundwater was encountered at Branx04 and therefore not water sample could be taken.

Table 4.3: Soil Samples – Laboratory Analysis

Sample ID	Nat. Grid Reference		Extractable N (mg/Kg)	Total Ca (mg/Kg)	Total Mg (mg/Kg)	Total P (mg/Kg)	Total K (mg/Kg)	Tot Moisture* 105°C (%)	Total N (mg/Kg)	Nitrate (mg/l)	Nitrogen (%)	Extractable P (mg/l)
Branx03A	NT 42297	10922	0.8	5210	12100	697	3850	62.4	<1	<0.2	0.43	<2
Branx03B	NT 42297	10922	0.7	1850	15700	356	2360	28.3	<0.9	<0.2	0.07	<2
Branx04A	NT 42301	11162	<0.5	12000	5100	615	1760	81	<0.7	<0.2	1.43	2.83
Branx04B	NT 42302	11163	<0.5	3080	14100	684	2800	21.7	<0.7	<0.2	0.06	<2
Branx06A	NT 42082	10906	<0.5	6390	1580	628	838	78.6	<0.7	<0.2	0.06	<2
Branx06B	NT 42082	10906	1.2	7930	1250	556	557	91.5	1.8	0.6	2.07	<2
Branx08A	NT 42156	11085	0.5	16200	2410	600	604	89.1	<0.7	<0.2	2.2	2.94
Branx08B	NT 42156	11085	0.6	19600	2820	371	824	93.1	<0.8	<0.2	1.94	<2

*** Total Moisture = Water content*
*A/B suffix: **A** = Rooting Zone and **B** = Below Root Zone*
Soil type not recorded for this site
Red figures denote samples that are above typical ranges for the observed dataset

5. SITE OBSERVATIONS

To enhance understanding of Branxholme Wester Loch and the surrounding area, preliminary research was undertaken and complemented with a second site walkover to further understand the landforms, drainage configurations, potential environmental sensitivities and possible diffuse pollution sources influencing the site from the catchment.

5.1 Desk Study

The Site Management Statement (SNH, 2010a) records an 'Objective for Management' of maintaining the extent, distribution and structure, function and processes of the open water transition fen (transition mires and floating bogs; alkaline fens) and the typical species of the habitats; and maintaining the extent, depth and condition of the oligotrophic loch.

The open water transition fen is in an unfavourable, declining status and the oligotrophic loch is in a favourable, maintained status based on the Site Management Statement in 2010 (SNH, 2010a). All the SAC features (Very wet mires, Base-rich fens and Slender green feather –moss) are in an unfavourable condition (SNH, 2010a).

Phragmites is spreading throughout the whole site (SNH, 2008b) and there is also encroachment by *Salix* and ericoids. There was also less than 10% open standing water in this mosaic also potentially indicating drying out (SNH, 2008a). Application of herbicides to control *Phragmites* in 2012 was agreed with the landowner (SNH, 2012).

Monitoring of the fen habitats in 2003 concluded that water levels in the loch might be too low, and in 2008 it was concluded there might still be drying out of some habitats. This may have been due to a change in the drainage pattern following felling and replanting of the adjacent plantation. The latter is due to scrub growth, indicative of long term natural succession to wet woodland. This has the more immediate effect of drying the local area and changing the specialised fen flora (SNH, 2010a). The drain which diverted water from the plantation has been blocked so water flows/infiltrates into the pond. Scrub and pine trees were felled in 2011 to assist in maintaining a higher water level in the pond. SNH have also recommended that a sluice is put in at the loch outflow to raise water levels (SNH, 2012).

Pollution from nutrient-rich runoff from adjacent heavily sheep-grazed pastures has been identified as a potential threat at the site. This is of concern, possibly more to the west of the site due to the presence of a limited buffer zone. The presence of 'shiny green alga' in October 2008 was interpreted as a potential increase in nutrient input (SNH, 2008c).

5.2 Catchment Walkover

From the second site visit post-receipt of the analytical results, the following observations of the surrounding catchment were made:

- The site was free of litter. No visible pollution sources were observed within the site boundary, apart from some cut wood.
- Unimproved pastures observed to the north and south of the site; some field drainage could be expected.
- Standing water on the site was generally clear, without any obvious indication of pollution.
- Forestry observed to the northeast of the site, with drainage network present.

- No properties were observed within the site catchment.

The land use information for the site from Land Cover Map 2007 (Figure 2.5) showed some inconsistencies with site observations.

5.3 Summary

The following table provides a summary of the key site features which were observed during the site visits undertaken as part of the initial study.

Table 5.1: Summary of key observations

Activities	Observations
Fencing	Fencing around the site (condition not assessed).
Fishing	Some unauthorised fishing takes place.
Grazing	Grazing in southern part of the site. Site catchment used for rough grazing and forestry.
Monitoring	Condition Monitoring was carried out in 2003, 2004 and 2008. Water quality monitoring undertaken by the Tweed River Purification Board in 1985 (Tweed River Purification Board, 1985).
Public Access	The site has no formal public access.
Shooting	Pheasant shooting; control of rabbits, roe deer, crows, pigeons and mink.
Point Pollution Sources	None observed within the SSSI boundary.
Properties in Catchment	There are no properties within the site catchment.
Unusual, Distinctive or Atypical Features	Forestry to the north and east of the site.

A mapped summary of the perceived catchment pressures is detailed in Figure 5.1 (see Annex 1).

6. INTERPRETATION OF RESULTS

The following assessment is based on the field tests and laboratory analytical results only.

6.1 General summary

Surface water and groundwater at the site was noted to contain low levels of phosphorus and nitrogen. However, spatial trends suggest a potential influence from grazing and forestry activities in the catchment particularly from the west of the site where livestock grazing is undertaken within the site boundary as described below.

All samples recorded pH levels alkaline or close to neutral, apart from groundwater at Branx06 which was slightly acidic, which could be due to a greater influence from rainfall or biodegradation processes at this location. Electrical conductivity was quite variable at the site with the highest value recorded in surface water sample at Branx07 to the southwest of the loch. The lowest value was recorded in the loch itself. Only two of the monitoring points (Branx01 & Branx02) were measured for dissolved oxygen due to a failure with the probe. The oxygen levels were considered to be moderate to high at these two locations.

Total nitrogen was typically low or below the limit of detection (LOD) in the majority of samples. The highest value was noted at Branx05 at 3.0mgl/l in the southern inlet stream to the loch, which is likely reflecting an input of nutrients from grazing in this area. All nitrate samples recorded results below the LOD with the exception of Branx01 in the loch, recording 0.3mg/l. Ammonia was typically low at around 0.01mg/l with the highest value recorded in Branx08 (groundwater) at 0.3mg/l. The distribution of nitrate and ammonia reflects the prevailing geochemical conditions in these environments (oxidising in surface water, reducing in groundwater).

Total phosphorus was generally below the LOD with the highest value recorded in Branx 06, in groundwater in the centre of the site, at 3.3 mg/l. Phosphate levels were variable with the highest values recorded at Branx03 and Branx06 which are both groundwater samples.

Iron levels were generally higher in the groundwater samples than the surface water which reflects the differing geochemical conditions encountered. Calcium levels were generally uniform with a slight trend noting slightly higher calcium in the west (05, 06 and 07) and lower calcium in the east (01, 02 and 03) with the highest value recorded in Branx08 (groundwater).

In soils the highest total nitrogen value was recorded in Branx08 (immediately north of the loch) in the root zone sample. All samples recorded nitrate below the LOD with the exception of Branx06B which recorded a value of 0.6mg/l. Total phosphorus was typically higher within the root zone samples. The majority of extractable phosphorus samples were recorded below the LOD with the exception of Branx04A and Branx08A both root zone samples. Both these sites are within the northern section of the wetland. Calcium levels were also noted to be higher in these areas (also in root zone samples) and may indicate the presence of insoluble calcium phosphate minerals.

6.2 Atypical results

The data from the Branxholme Wester Loch site were generally fairly uniform with the exception of the following results:

- Branx08 recorded a calcium value of 19,600mg/kg in the below root zone sample and is considered to reflect the natural geology/hydrogeology of the area.

- Branx03B and Branx04B recorded elevated levels of magnesium which is also considered to reflect the natural geology/hydrogeology of the area.

6.3 Additional considerations

Water quality monitoring was undertaken at Branxholme Wester Loch by the Tweed River Purification Board in April, May and July 1985 (Tweed River Purification Board, 1985). Samples were analysed for pH, nitric nitrogen (nitrate), free and saline ammonia (ammoniacal nitrogen), soluble phosphate, total hardness and iron, with the following concentration ranges recorded:

- pH: 7.65-8.15 – consistent with the level recorded at Branx01 in the loch.
- Nitrate as N: 0.10-0.25 mg/l – a slightly higher level was recorded at Branx01.
- Ammoniacal N as N: 0.01-0.03 mgl – consistent with the level recorded at Branx01.
- Soluble phosphate as P: 0-0.18 mg/l – consistent with the concentration of phosphate recorded at Branx01.
- Total hardness as $CaCO_3$: 110-116 mg/l – not measured for this study.
- Iron as Fe: 0.05-0.09 mg/l – a lower level was recorded at Branx01.

As detailed above, most readings were in general consistent with concentrations recorded at Branx01 for this study.

Branxholme Wester Loch was also surveyed by Jones (n.d.) as part of a study in the Scottish Borders region undertaken between 1983 and 1986. It was indicated that pH was relatively high (~7.5) as was conductivity (0.164mS/cm) – indicative of mineral rich conditions, but phosphorus (0.0176mg/l), nitrogen (0.01mg/l) , silica and chlorophyll were all fairly low. This, again, is consistent with the findings of this study.

There is no indication of algal blooms in the loch and no records or reports (anecdotal or otherwise) were reviewed during this study.

7. CONCLUSIONS

The analytical results showed a trend of moderate to elevated nutrients in surface water and groundwater within the site, with a potential influence from grazing and forestry activities in the catchment, particularly from grazing in the western section of the site.

The site sits in a basin and collects drainage from a 0.4km^2 catchment, managed for extensive grazing (sheep and cattle) and forestry. There are no properties located within the site catchment.

The site is a component of the Whitlaw and Branxholme Special Area of Conservation (SAC). The open water transition fen is in an unfavourable, declining status, mainly due to the drying out of the site and vegetation encroachment, including spreading of reeds (reflecting normal succession of the habitat). Standing water on the site has also reduced. The plantation was felled and re-stocked with conifers in 2002 and drainage from this area was diverted around the site during these works. This could have affected the water balance at the site, reducing the inflow of water, but has been remediated through blocking of drains. Chemical control of vegetation (including reed) was agreed in 2012.

Low total nitrogen and nitrate levels were recorded across the site (up to 3mg/l and 0.3mg/l respectively). Slightly more elevated levels of total nitrogen in the main inlet stream to the southwest of the loch are likely reflecting an input of nutrients from grazing in this area.

Total phosphorus was below the analytical level of detection (0.1mg/l) in surface water, with higher levels observed in groundwater, particularly to the west of the loch. Phosphate levels were low to moderate, with highest values in groundwater and low levels in the loch (<0.01mg/l). The overall trend shows more elevated nutrient levels to the west of the loch.

8. RECOMMENDATIONS

Based on the understanding gained from the sampling exercise and catchment visits, the following recommendations are proposed:

8.1 Monitoring

i. Undertake a long-term targeted monitoring study at selected locations within the site for key nutrients – to include orthophosphate and bioavailable (extractable) nitrogen. Ideally this would be undertaken over the course of several seasons (ideally for a minimum of one year). This should be compared alongside surface and groundwater levels, rainfall data and seasonal abnormalities to seek to understand the hydrological and nutrient dynamics taking place within the site. In conjunction with this, assess the seasonal flow and nutrient loads of the main inflows and regional groundwater.

8.2 Other Commissioned Studies

ii. Undertake hydrological and hydrogeological assessment of the contributing catchment in order to determine the quality and quantity of the source flows and improve understanding of any recent changes in water balance and levels (*i.e.* drying out of site).

iii. Assess the potential effects on vegetation, hydrology and nutrient regime of raising or reducing the water table on the site.

iv. Further assess the link between vegetation encroachment and diffuse pollution.

v. Undertake a detailed library review, including historical mapping and local data sources, to seek to understand historical land use and information relating to the site, including peat cutting and drainage on the site and its surrounds.

8.3 Landowners

vi. Proactively engage with local landowners to understand the existing and (foreseeable) proposed changes to the immediate catchment, particularly regarding grazing within and in proximity of the site and forestry activities. Consider appropriate management strategies accordingly - for example, buffer strips, exclusion zones, scrub cutting, reed control, routine spot monitoring, improved fencing *etc*.

From the stated conclusions and identified pressures (Figure 5.1) the key actions to seek to reverse the present unfavourable status of the site are to:

1. Ascertain the link between reed encroachment and diffuse pollution (i, iv);
2. Assess hydrological and hydrogeological conditions at the site including recent changes to water balance/ levels and proposed changes in water levels in the loch (ii, iii); and
3. Address the inputs to water from agricultural (and forestry) activities, particularly to the west of the loch (vi).

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ANNEX 1: FIGURES

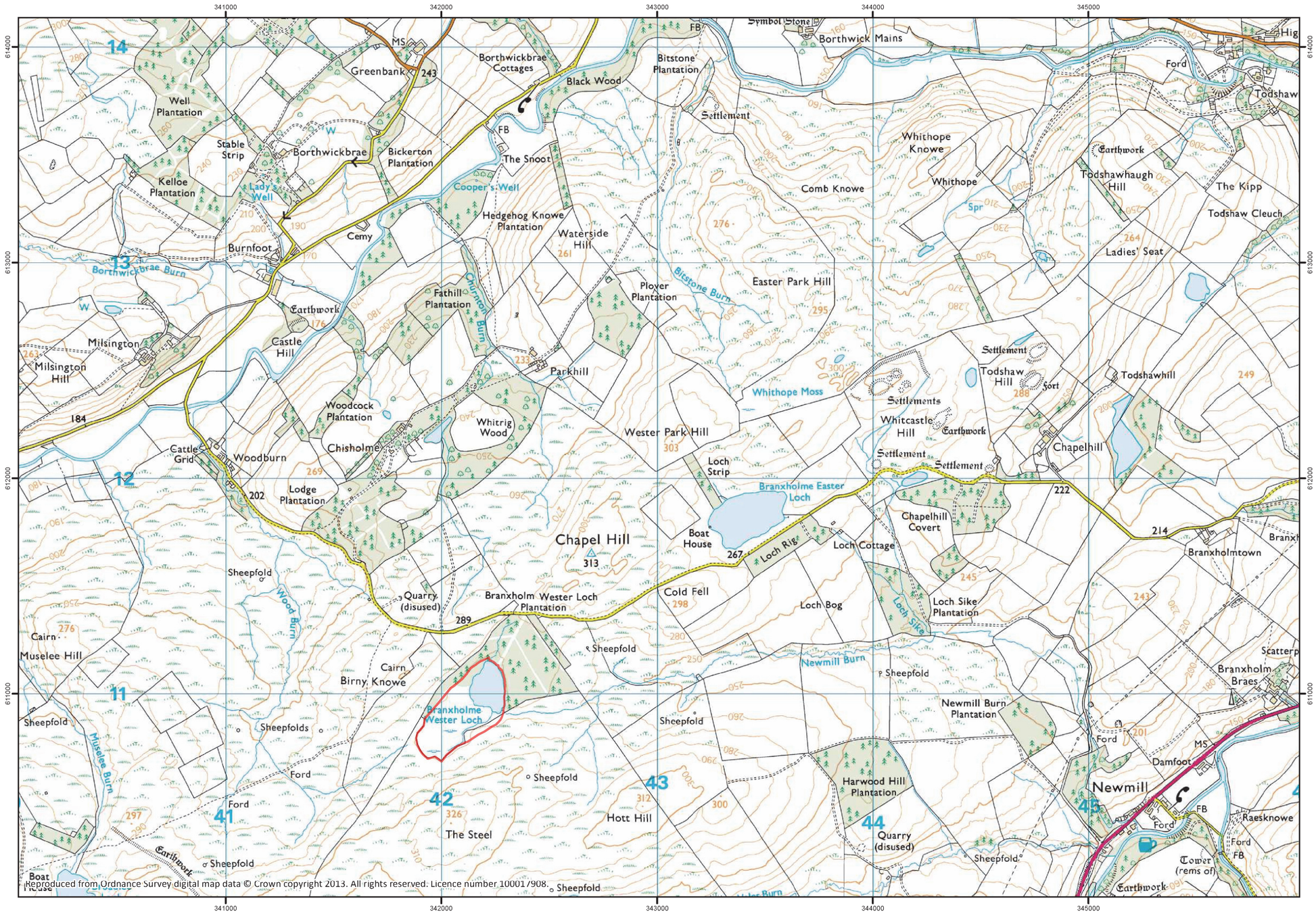


Figure 1.1: Site Location Map

Wester Branxholme

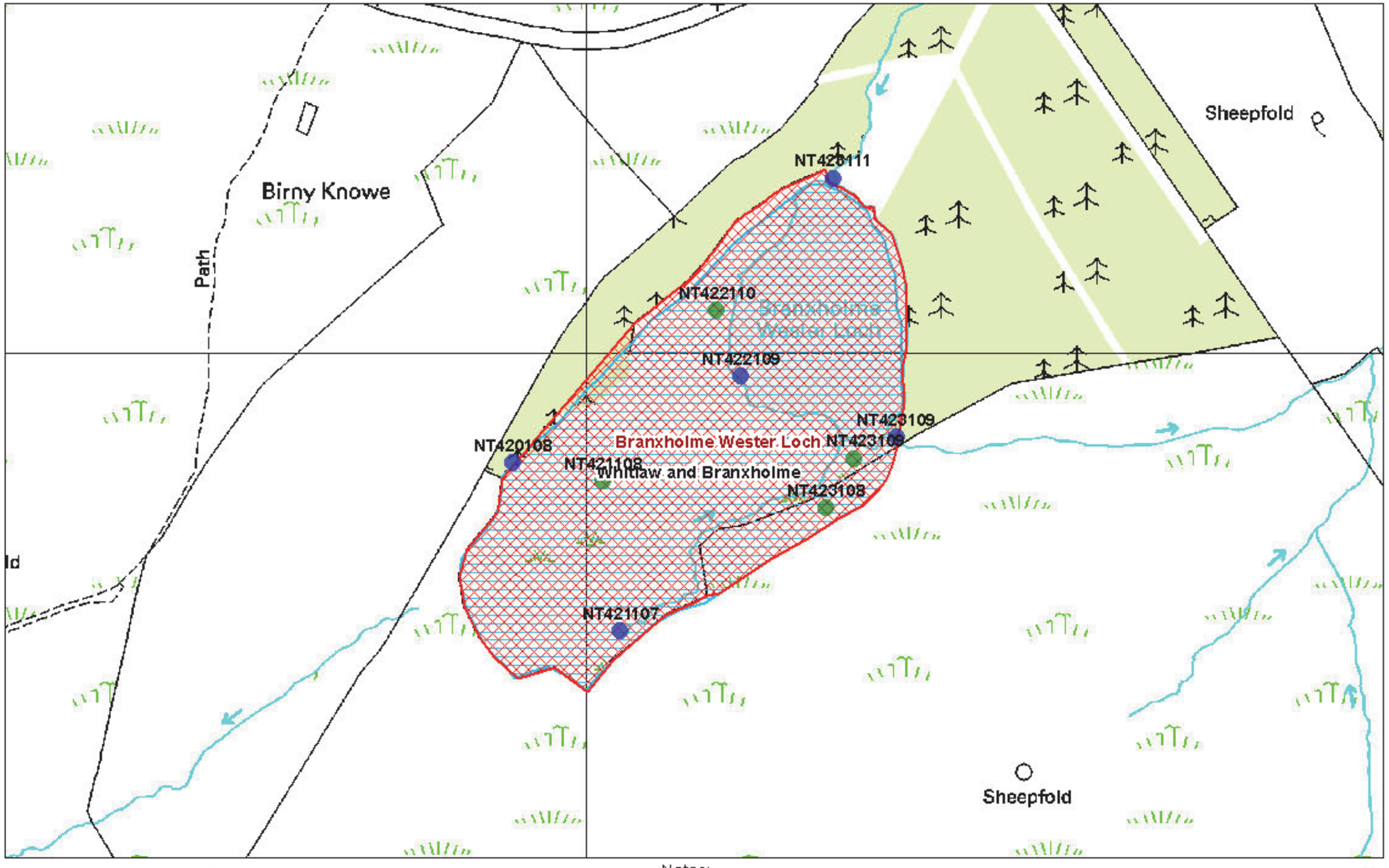


Figure 2.1: SNH Proposed Sample Location Plan

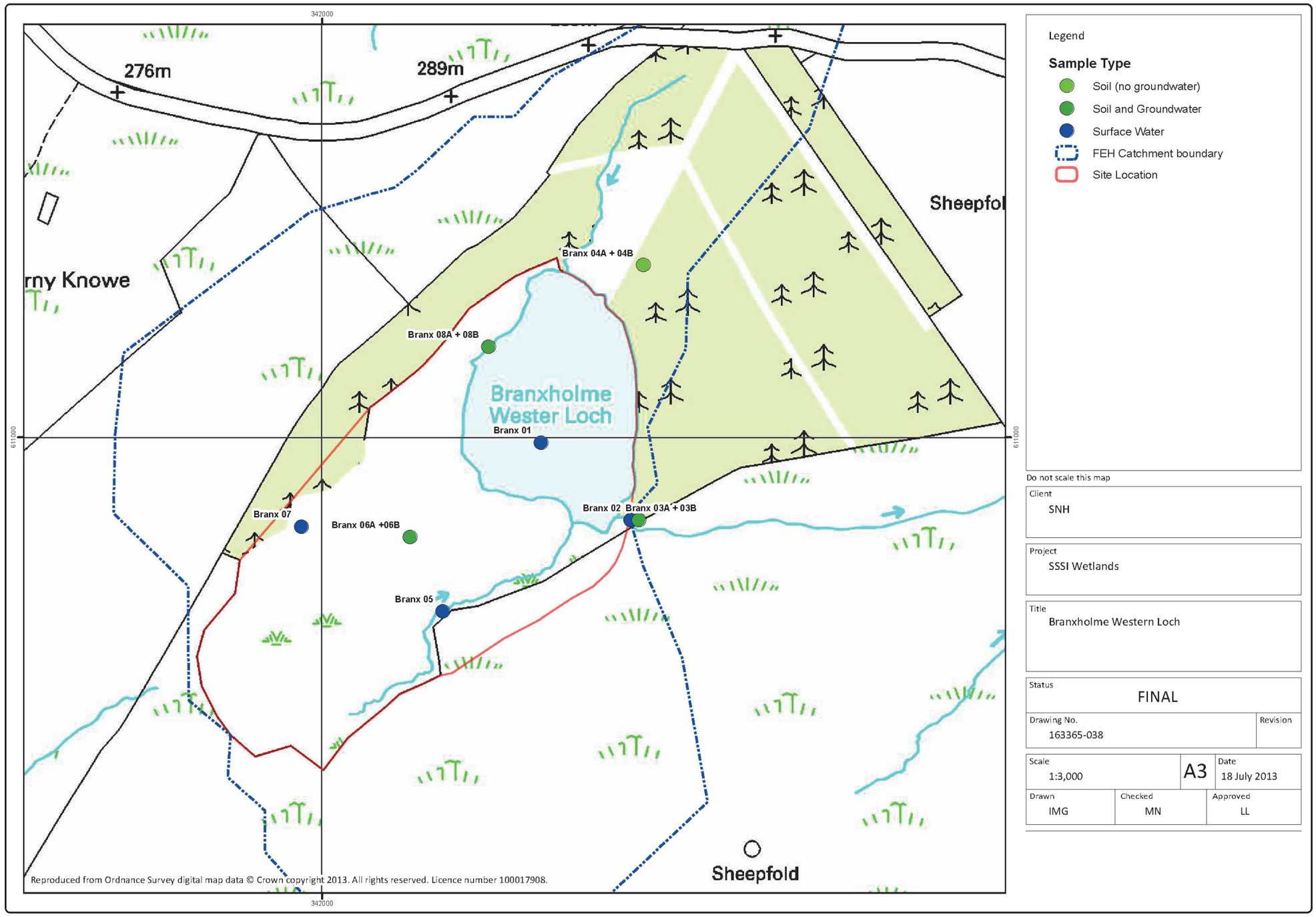


Figure 2.2: Plan of Actual Sampled locations

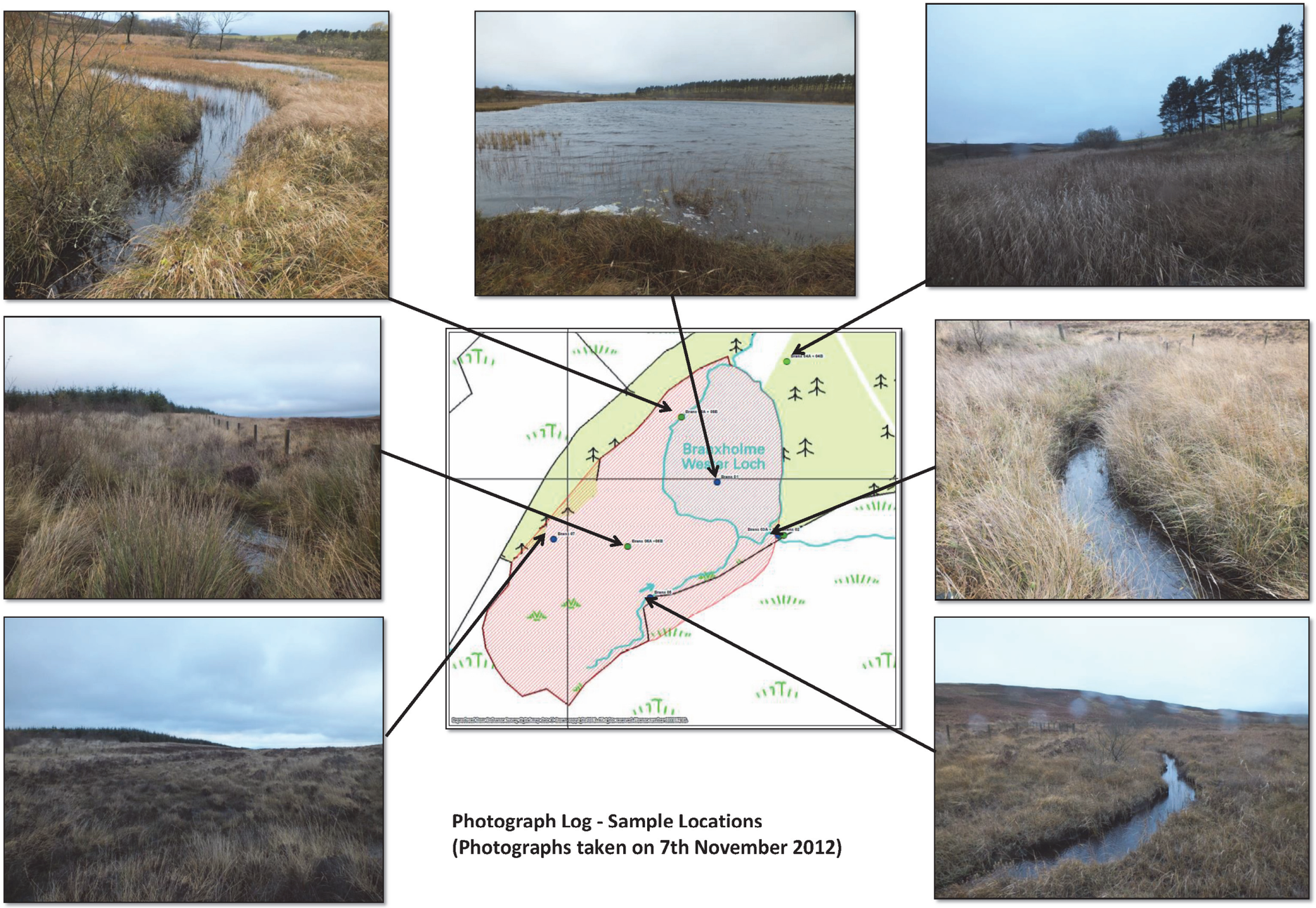


Figure 2.3: Photographs of each sampling Location

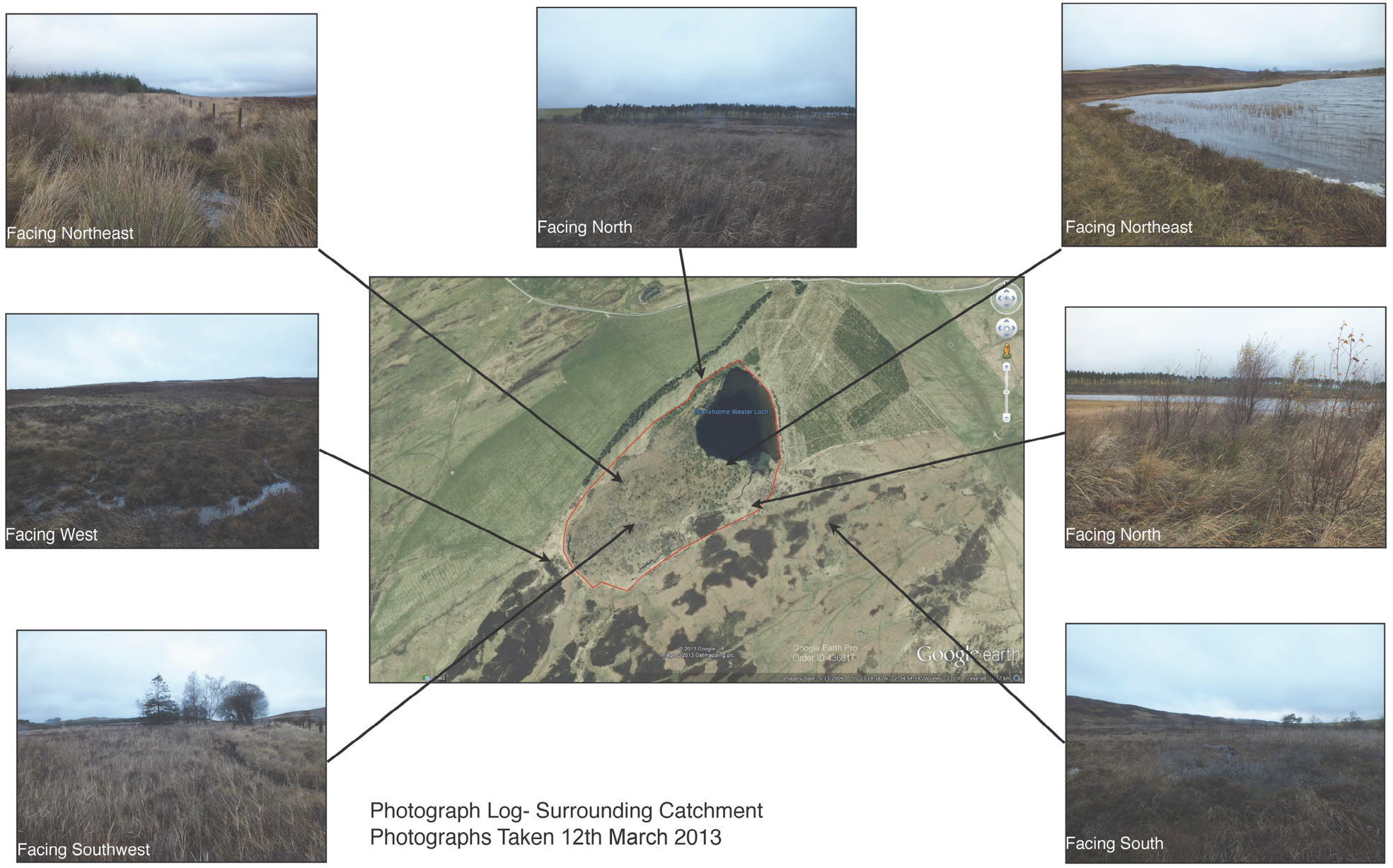


Figure 2.4: Photographs of surrounding land use

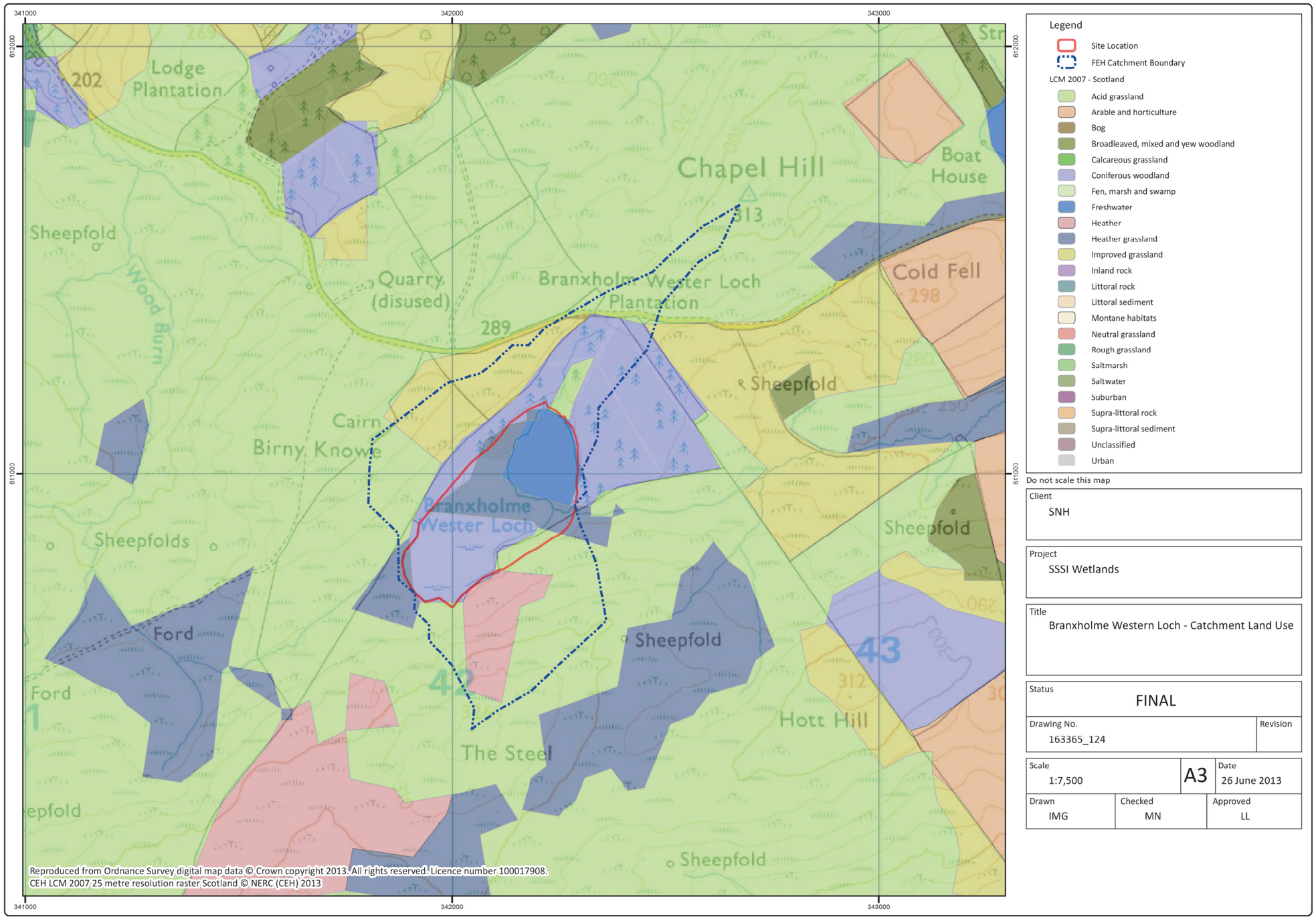
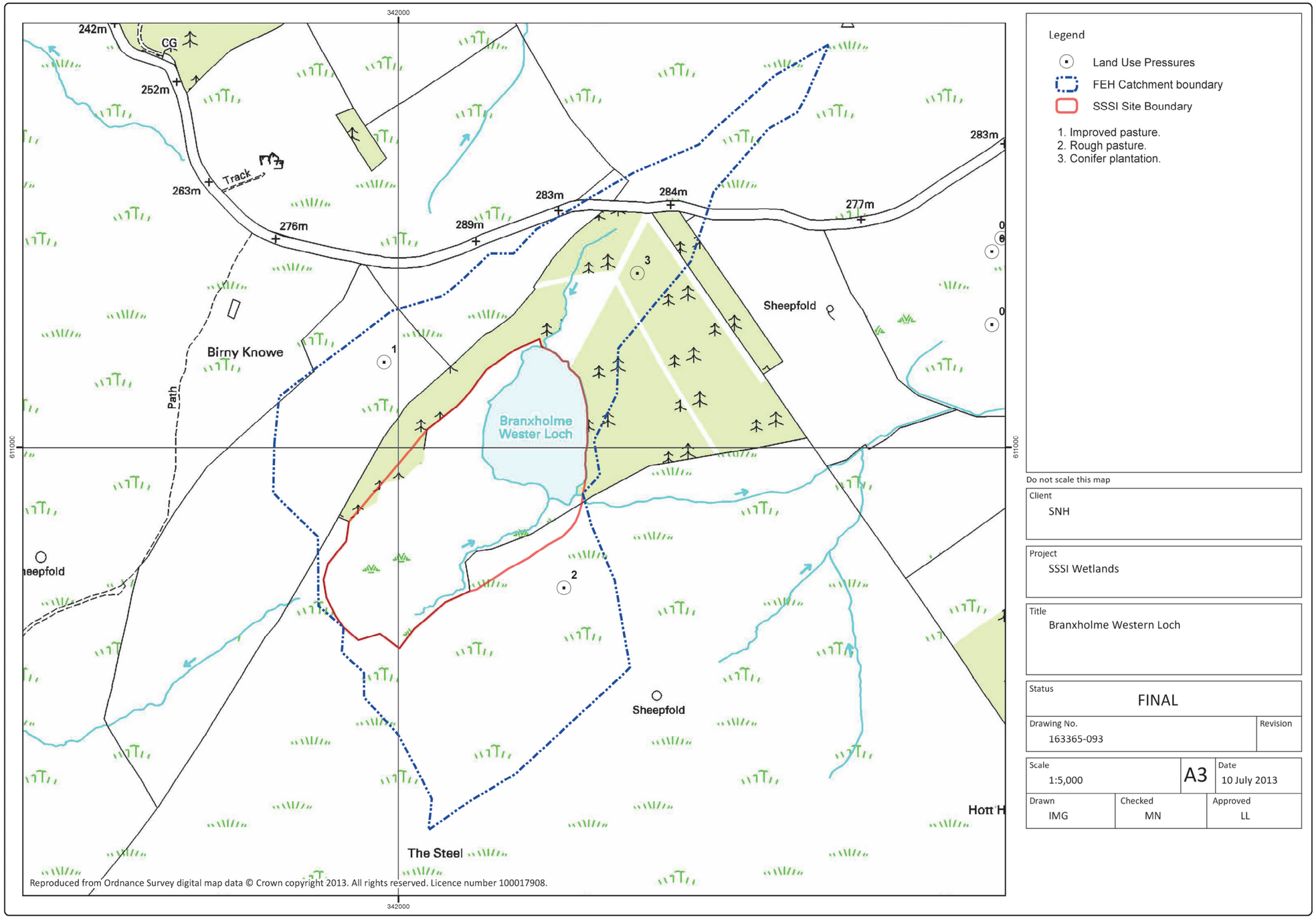


Figure 2.5: Catchment Land Use Characteristics



Legend

- Land Use Pressures
- FEH Catchment boundary
- SSSI Site Boundary

1. Improved pasture.
2. Rough pasture.
3. Conifer plantation.

Do not scale this map

Client: SNH			
Project: SSSI Wetlands			
Title: Branxholme Western Loch			
Status: FINAL			
Drawing No.: 163365-093		Revision:	
Scale: 1:5,000	A3	Date: 10 July 2013	
Drawn: IMG	Checked: MN	Approved: LL	

Figure 5.1: Catchment Pressures Summary

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